

CS ~~and~~ ~~9~~ d) selectively etching the semiconductor substrate through the opening in the dielectric layer.

(Annotated claims listed in the back)

Remarks

Claims 1-32 are pending and rejected. Applicant requests cancellation of claims 7, 13, 22, 23, and 29. Applicant amends the independent claims 1, 9, 15, 24 and 31 and requests reconsideration and allowance of claims 1-6, 8-12, 14-21, 24-28, and 30-32.

Indication of Allowable Subject Matter

Applicant wishes to thank the Examiner for the indication of allowable subject matter for the above referenced application. Applicant understands the allowable subject matter to include: forming a layer of germanium over a dielectric stack; removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask; and etching the dielectric layer through the germanium hardmask. Applicants have amended all independent claims (claims 1, 9, 15, 24 and 31) to include the allowable subject matter and have canceled claims 7, 13, 22, 23, and 29, which are the previously depending claims that contained that allowable subject matter in whole or in part. Remaining depending claims all contain, by virtue of their dependency, the allowable subject matter. Applicants believe that the application is now in condition for allowance and respectfully request the same.

Rejections under USC § 103(a): claims 1, 9, 15, 24, and 31

The independent claims, being claims 1, 9, 15, 24 and 31 were rejected by the Examiner under 35 U.S.C. § 103(a) as being unpatentable over Angelopoulos et al. (U.S. Patent No. 6,316,167, hereinafter "Angelopoulos") in view of Cho et al. (U.S. Patent No.

6,074,930, hereinafter "Cho") and Juengling (U.S. Patent No. 5,750,442, hereinafter "Juengling").

Claim 1 has been amended to include the allowable subject matter of claims 22 and 7. Claim 9 has been amended to include the allowable subject matter of claims 23 and 13. Claim 15 has been amended to include the allowable subject matter of "removing a photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask." The remaining elements of claim 15 cover the allowable subject matter identified by the Examiner. Claim 24 has been amended to include the allowable subject matter. Claim 31 has been amended to include the allowable subject matter.

Rejections under USC § 103(a): claims 2-8, 10-14, 16-21, 25-30, and 32

Claims 7, 13, and 29 are canceled. The remaining dependent claims 2-6, 8, 10-12, 14, 16-21, 25-28, 30, and 32 are allowable as depending from allowable independent claims.


In summary, none of the references cited by the Examiner nor any other known prior art, either alone or in combination, disclose the unique combination of features disclosed in applicant's claims presently on file. For this reason, allowance of all of applicant's claims is respectfully solicited.

Applicants hereby declare that any amendments herein that are not specifically made for the purpose of patentability are made for other purposes, such as clarification, and that no such changes shall be construed as limiting the scope of the claims or the application of the Doctrine of Equivalents.

If any fees, including extension of time fees, are due as a result of this response, please charge IBM Corp Deposit Account No. 09-0456. This authorization is intended to act as a constructive petition for an extension of time, should an extension of time be needed as a result of this response. The examiner is invited to telephone the undersigned if this would in any way advance the prosecution of this case.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Claim 1. (Thrice Amended) A method for etching a semiconductor substrate using a germanium hard mask, the semiconductor substrate having a dielectric layer over a major surface thereof, the method comprising the steps of:

- a) depositing a layer of metallic germanium over the dielectric layer;
- b) patterning the layer of metallic germanium to form the germanium hard mask as a top most layer over the dielectric layer, the step further comprising:
 - i) depositing a photo resist layer over the layer of metallic germanium;
 - ii) exposing and developing the photo resist layer to form a photolithography image; and
 - iii) etching the layer of metallic germanium through the photolithography image;
- c) removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask
- d) selectively etching [the] a dielectric layer through the germanium hard mask with the germanium hard mask as a top most layer to form an opening in the dielectric layer; and
- e) selectively etching the semiconductor substrate through the opening in the dielectric layer.

Claim 2. (Unchanged) The method as claimed in claim 1, further comprising the step of stripping away the layer of metallic germanium after performing the step of selectively etching the dielectric layer.

Claim 3. (Unchanged) The method as claimed in claim 2, the step of stripping away the layer of metallic germanium including the steps of:

oxidizing the layer of metallic germanium to form a layer of germanium oxide therefrom; and
removing the layer of germanium oxide.

Claim 4. (Unchanged) The method as claimed in claim 3, the step of removing the layer of germanium oxide including rising the semiconductor substrate in water.

Claim 5. (Unchanged) The method as claimed in claim 2, the step of stripping away the layer of metallic germanium including stripping away the layer of metallic germanium before performing the step of selectively etching the semiconductor substrate.

Claim 6. (Unchanged) The method as claimed in claim 1, the step of depositing a layer of metallic germanium including depositing the layer of metallic germanium having a thickness between approximately 40 nm and approximately 500 nm.

Claim 7. (Canceled) The method as claimed in claim 1, the step of patterning the layer of metallic germanium further including the steps of:

depositing a photo resist layer over the layer of metallic germanium;
exposing and developing the photo resist layer to form a photolithography image;
and
etching the layer of metallic germanium through the photolithography image.

Claim 8. (Unchanged) The method as claimed in claim 1, the step of forming a dielectric layer further including the steps of:

forming a pad oxide layer having a thickness between approximately 5 nm and approximately 30 nm over the major surface of the semiconductor substrate;

depositing a nitride layer having a thickness between 50 nm and approximately 300 nm over the pad oxide layer; and

depositing a mask oxide layer having a thickness between 800 nm and approximately 3,000 nm over the nitride layer.

Claim 9. (Thrice Amended) A method for fabricating a semiconductor device having a dielectric stack over a major surface thereof, comprising the steps of:

- a) depositing a metallic germanium layer over the dielectric stack;
- b) patterning the metallic germanium layer to form a germanium hard mask as a top most layer over the dielectric stack, the step further comprising:
 - i) depositing a photo resist layer over the metallic germanium layer;
 - ii) exposing and developing the photo resist layer to form a photolithography image; and
 - iii) etching the metallic germanium layer through the photolithography image;
- c) removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask
- d) etching the dielectric stack through the germanium hard mask with the germanium hard mask as a top most layer to form a dielectric hard mask over the major surface of the semiconductor substrate;
- e) etching the semiconductor substrate through the dielectric hard mask;
- f) forming doped regions in the semiconductor substrate; and
- g) forming dielectric and conductive structures over the semiconductor substrate.

Claim 10. (Unchanged) The method as claimed in claim 9, further comprising the step of stripping away the metallic germanium layer after the step of etching the dielectric stack and before the step of etching the semiconductor substrate.

Claim 11. (Unchanged) The method as claimed in claim 10, wherein the step of stripping away the metallic germanium layer includes the steps of:

- oxidizing the metallic germanium layer; and
- rising the semiconductor substrate in water.

Claim 12. (Unchanged) The method as claimed in claim 9, wherein the step of depositing a metallic germanium layer includes depositing the metallic germanium layer having a thickness between approximately 40 nm and approximately 500 nm in a chemical vapor deposition process.

Claim 13. (Canceled) The method as claimed in claim 9, wherein the step of patterning metallic germanium layer further includes the steps of:

- depositing a photo resist layer over the metallic germanium layer;
- exposing and developing the photo resist layer to form a photolithography image;
- and
- etching the metallic germanium layer through the photolithography image.

Claim 14. (Unchanged) The method as claimed in claim 9, wherein the step of forming a dielectric stack further includes the steps of:

- forming a pad oxide layer having a thickness between approximately 5 nm and approximately 30 nm on the major surface of the semiconductor substrate;
- depositing a nitride layer having a thickness between 50 nm and approximately 300 nm on the pad oxide layer; and
- depositing a mask oxide layer having a thickness between 800 nm and approximately 3000 nm on the nitride layer.

Claim 15. (Twice Amended) A method for etching a semiconductor wafer, the semiconductor wafer having a dielectric stack over a major surface thereof, the method comprising the steps of:

- a) forming a germanium hard mask as a top most layer over the dielectric stack, the step comprising depositing a photo resist layer over the metallic germanium layer;
- b) removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask;
- c) etching the dielectric stack through the germanium hard mask to form a dielectric hard mask over the major surface of the semiconductor wafer; and
- d) etching the semiconductor wafer through the dielectric hard mask.

Claim 16. (Unchanged) The method as claimed in claim 15, wherein the step of forming a germanium hard mask includes the steps of:

- depositing a layer of metallic germanium having a thickness equal to or greater than approximately 40 nm over the dielectric stack;
- patterning the layer of metallic germanium to form the germanium hard mask.

Claim 17. (Unchanged) The method as claimed in claim 16, wherein the step of patterning the layer of metallic germanium further includes the steps of:

- depositing a photo resist layer over the layer of metallic germanium;
- patterning the photo resist layer to form a photolithography mask; and
- etching the layer of metallic germanium through the photolithography mask.

Claim 18. (Unchanged) The method as claimed in claim 16, further comprising the step of stripping away the germanium hard mask after etching the dielectric stack and before etching the semiconductor wafer.

Claim 19. (Unchanged) The method as claimed in claim 18, wherein the step of stripping away the germanium hard mask includes the steps of:
oxidizing the layer of metallic germanium to convert the layer of metallic germanium into a layer of germanium oxide; and
removing the layer of germanium oxide.

Claim 20. (Unchanged) The method as claimed in claim 19, wherein the step of removing the layer of germanium oxide includes rising the semiconductor wafer in water.

Claim 21. (Unchanged) The method as claimed in claim 1, wherein the step of patterning the layer of metallic germanium comprises:
depositing a layer of photo resist;
etching the metallic germanium layer through the layer of photo resist; and
removing the layer of photo resist prior to the step of selectively etching the dielectric layer through the germanium hard mask

Claim 22 (Canceled) The method of claim 7, further comprising removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask.

Claim 23 (Canceled) The method of claim 13, further comprising removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask

Claim 24. (Amended) A method for etching a semiconductor substrate having a dielectric layer over a major surface thereof, the method comprising the steps of:

- a) depositing a layer of germanium over the dielectric layer;
- b) depositing a photoresist layer over the germanium layer;
- c) exposing and developing the photo resist layer to form a photolithography image;
- d) etching the metallic germanium layer through the photolithography image
[patterning the layer of metallic germanium through the photoresist layer] to form a germanium hard mask over the dielectric layer;
- e) removing the photoresist layer from over the germanium hard mask;
- f) patterning the dielectric layer through the germanium hard a mask after removing the photoresist layer from over the germanium hard mask to form a dielectric hard mask over the semiconductor substrate; and
- g) selectively etching the semiconductor substrate through the dielectric hard mask.

Claim 25. (Unchanged) The method as claimed in claim 24, further comprising the step of stripping away the germanium hard mask after patterning the dielectric layer to form the dielectric hard mask.

Claim 26. (Unchanged) The method as claimed in claim 25, wherein stripping away the layer of germanium comprises:

oxidizing the layer of germanium to form a layer of germanium oxide therefrom;
and
removing the layer of germanium oxide.

Claim 27. (Unchanged) The method as claimed in claim 26, wherein removing the layer of germanium oxide comprises rinsing the semiconductor substrate in water.

Claim 28. (Unchanged) The method as claimed in claim 24, wherein depositing a layer of germanium comprises depositing the layer of germanium having a thickness between approximately 40 nm and approximately 500 nm.

Claim 29. (Canceled) The method as claimed in claim 24, wherein patterning the layer of germanium further comprises:

exposing and developing the photoresist layer to form a photolithography image;
and
etching the layer of metallic germanium through the photolithography image.

Claim 30. (Unchanged) The method as claimed in claim 24, further comprising forming a dielectric layer by:

forming a pad oxide layer having a thickness between approximately 5 nm and approximately 30 nm over the major surface of the semiconductor substrate;

depositing a nitride layer having a thickness between 50 nm and approximately 300 nm over the pad oxide layer; and

depositing a mask oxide layer having a thickness between 800 nm and approximately 3,000 nm over the nitride layer.

Claim 31. (Amended) A method for etching a semiconductor substrate having a dielectric layer over a major surface thereof, the method comprising the steps of:

- a) depositing a layer of germanium over the dielectric layer;
- b) patterning the layer of germanium to form a germanium hard mask, the step further comprising:
 - i) depositing a photo resist layer over the metallic germanium layer;
 - ii) exposing and developing the photo resist layer to form a photolithography image;
 - iii) etching the metallic germanium layer through the photolithography image; and
 - iv) removing the photoresist layer prior to selectively etching the dielectric layer through the germanium hard mask;;
- c) patterning the dielectric layer through the germanium hard mask using a process selective to germanium to form an opening in the dielectric layer; and
- d) selectively etching the semiconductor substrate through the opening in the dielectric layer.

Claim 32. (Unchanged) The method as claimed in claim 31, further comprising the step of stripping away the germanium hard mask after patterning the dielectric layer.